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LARGE AREA CROP INVENTORY EXPERIMENT (LACIE)

NASA NOAA USDA

WHEAT YIELD MODELS FOR THE UNITED STATES

National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

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DOCUMENT

PREPARED BY

NOAA PERSONNEL

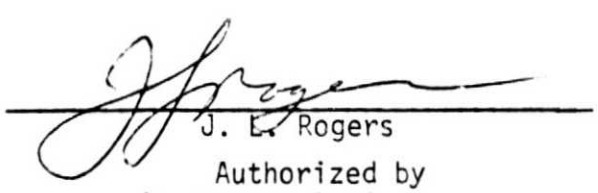
CENTER FOR CLIMATIC AND ENVIRONMENTAL ASSESSMENT

COLUMBIA, MISSOURI

TECHNICAL NOTE 77-1

YIELD MODELS FOR THE UNITED STATES

APRIL 1977



J. E. Rogers

Authorized by
for Norton D. Strommen
Director, CCEA
June 10, 1977

CCEA Crop/Weather Models for the Great Plains Region

Crop/weather models for wheat have been developed for the Great Plains region of the United States. The enclosed maps indicate the areal coverage of the various models for spring (durum and other spring) and winter wheat (Figures 1 and 2). The given regions are the combination of several climatic divisions and many times comprise an entire state.

Data Base

The yield and climatic data base used to derive all of the models but one is approximately 45 years in length. The yield data, from 1932-1975, are obtained by aggregating the USDA/SRS estimates of harvested acreage and production to obtain yields in quintals per harvested hectare for a given region. The climatic data, from 1931-1975, consist of the NOAA/EDS/NCC monthly climatic division averages of precipitation and temperature. These averages are weighted, using acres harvested for 1973, to obtain the monthly average temperature and total precipitation for a given region. The data base for the Edwards Plateau model covers the same time period except in the coastal border and south central districts where only the period 1961-1975 is used. The data are not weighted.

Trend of Yields

A piecewise linear curve is used to model the technology trend. The year 1955 is assumed to be the approximate time at which wheat yields started to increase rapidly. This is consistent with the fact that little fertilizer was applied to wheat in the Great Plains region prior to the early 1950's. There is significant evidence that for some regions wheat yields have leveled off in recent years. For example, Oklahoma yields appear to have rapidly increased from 1955 to 1960, but have shown little or no increase from 1960

Spring Wheat Model Areas

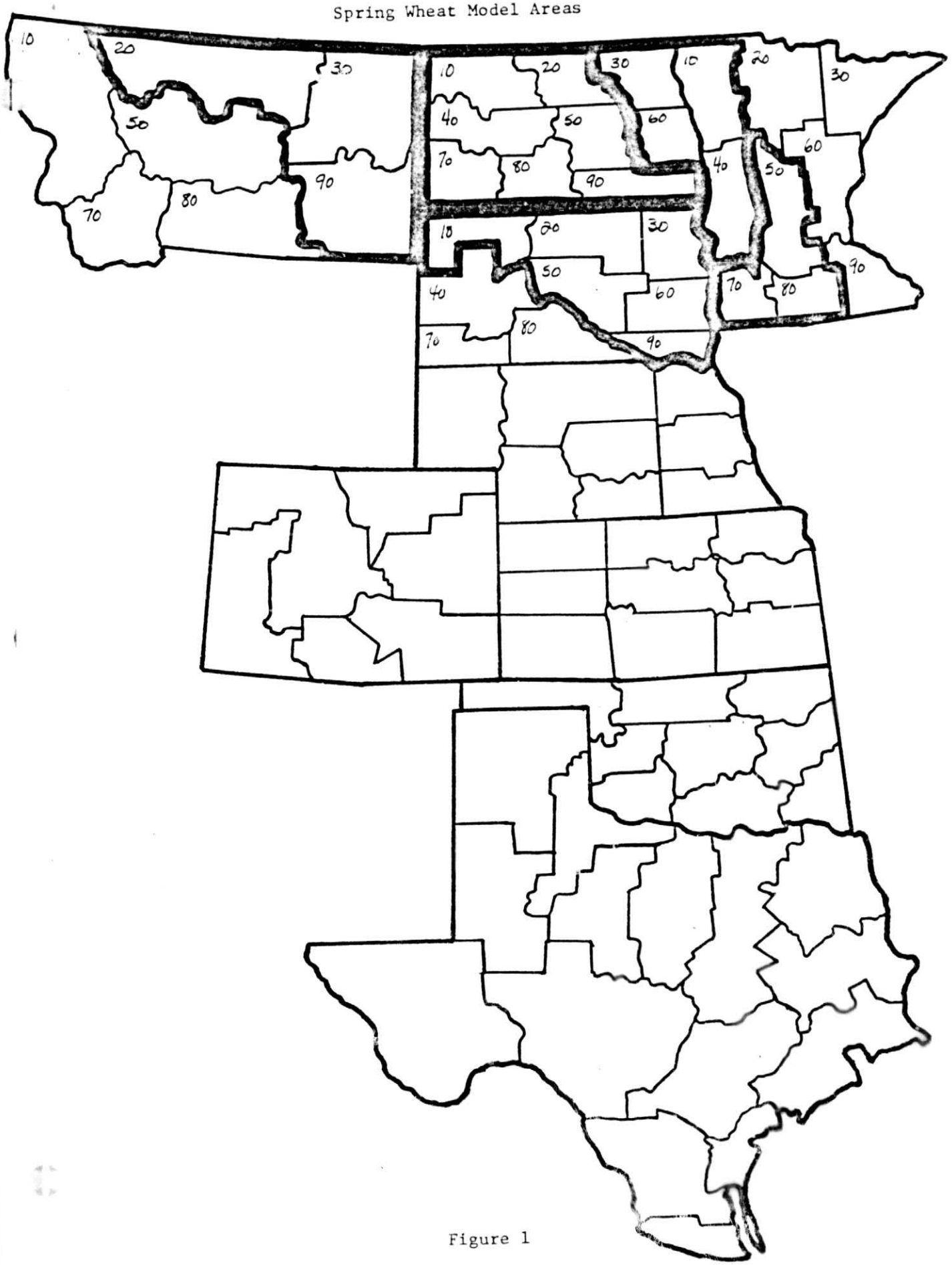


Figure 1

Winter Wheat Model Areas

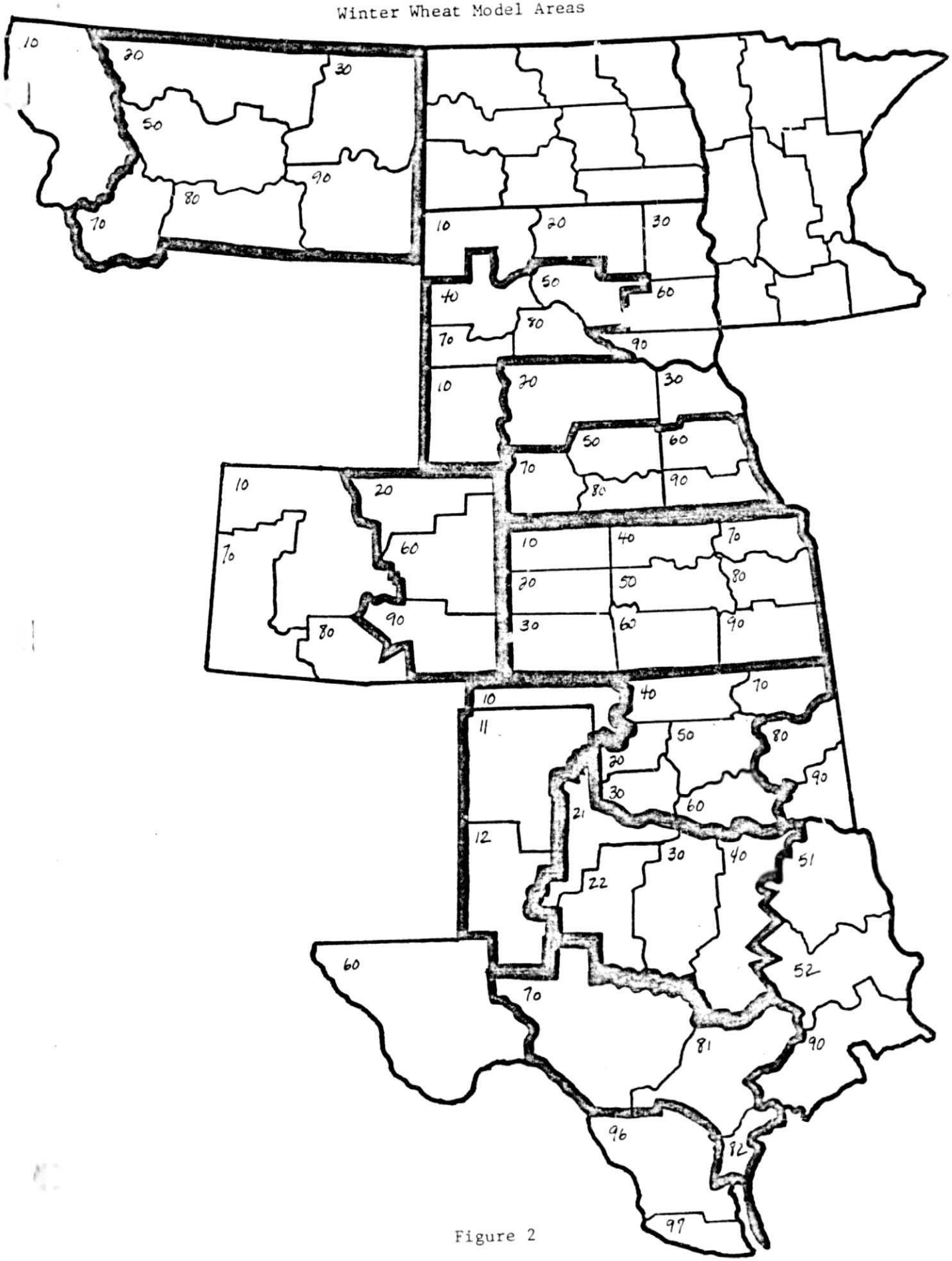


Figure 2

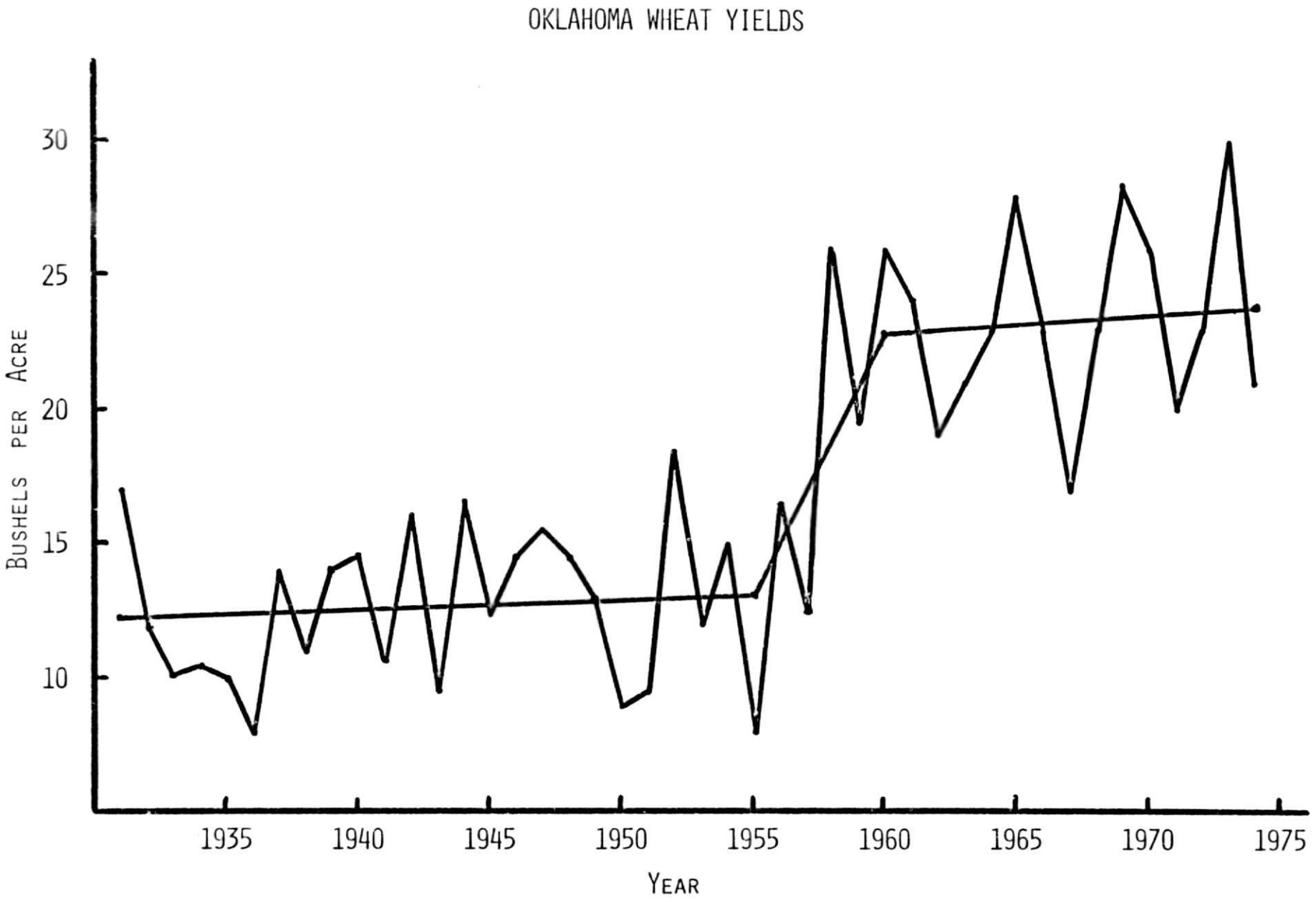

OKLAHOMA WHEAT YIELDS
BUSHELS PER ACRE
30
25
20
15
10
1935
1940
1945
1950
1955
1960
1965
1970
1975
YEAR

FIGURE 3

onward (Figure 3). Therefore, the models use one linear trend up to 1955 and one or more linear trends from 1955-1960.

Climatic Variables

The relationship between wheat yields and certain climatic variables is known to be non-linear. For example, too little or too much precipitation may be detrimental to wheat yields. In order to approximate this relationship, the climatic variables are coded in terms of departures from normal (DFN) and squared departures from normal (SDFN). Here normal is defined as the long term average of the climatic variable over the entire length of the historical data base.

For months in which both temperature and precipitation appear to make important contributions to wheat yields, an aridity index is constructed. Temperature is converted into potential evapotranspiration (P.E.T.) using Thornthwaite's method, which requires only the monthly average temperature as the climatic input. The index is computed either by subtracting monthly P.E.T. from monthly precipitation or by dividing monthly precipitation by monthly P.E.T.

Wheat yields are lowered when the crop is subjected to episodes of hot dry weather during the heading stage. The variable "degree days above 90°F" is used during the month or months which most closely approximate the time of heading in a given region. It is obtained by averaging the degree day values for several stations within the region. The actual number of degree days is converted to a stress index (0-1 variable) by defining stress (=1) to have occurred if the degree day value exceeds a predetermined threshold. Otherwise, it is assumed that no stress (=0) has occurred.

The write-ups for the various models, listing the variables and coefficients, are included at the end of this report. For use in forecasting

yields throughout the crop season, truncated models are given in which regression coefficients are estimated using only climatic variables through a given cut-off point. For example, if the time of truncation is March, the coefficients are estimated using only the climatic variables through the month of March.

Note that the variables change among the various models. Since wheat yields have continued to increase in some states, while apparently leveling off in others, different choices of trend lines are used to represent the technology curve. Because of changes in the crop calendar from state to state, the climatic variables used in the model also may vary.

The Texas Edwards Plateau model uses the combined yield for the coastal border and south central districts. These yields are separate independent observations in the same model. Allowance is made for a shift in yield level between the two combined districts and the Edwards Plateau district. The response to meteorological inputs is assumed to be the same.

APPENDIX I

CCEA Great Plains Crop/Weather Models

	Region	Type of Wheat
1.	Badlands (Nebraska/South Dakota)	Winter
2.	Colorado	Winter
3.	Kansas	Winter
4.	Minnesota	Spring
5.	Montana	Winter
6.	Montana	Spring
7.	Nebraska	Winter
8.	North Dakota	Spring
9.	Oklahoma	Winter
10.	Panhandle (Oklahoma/Texas)	Winter
11.	Red River (Minnesota/North Dakota)	Spring
12.	South Dakota	Spring
13.	Texas Low Plains	Winter
14.	Texas Edwards Plateau	Winter

BADLANDS WINT WHEAT MODEL

Crop District	Weight
10 Panhandle (Nebraska)	.6228

Crop District	Weight
40 West Central (South Dakota)	.1351
70 Southwest (South Dakota)	
50 Central (South Dakota)	.1974
80 South Central (South Dakota)	.0447

P.E.T. A = 1.188
P.E.T. I = 43.958

March Daylength = .9833
April Daylength = 1.1087

Latitude = 43°N

June Degree Days Greater Than 90F = 1 if degree days greater than 25, otherwise 0

Degree Day Stations: Nebraska: Bridgeport, Harrison; South Dakota: Pierre, Rapid City

Variable		Normal	Trend	November	Truncation March	Truncation April	Truncation June	Truncation July
Overall Constant		1.00	5.27251	5.92882	6.10211	5.60069	6.24340	5.95108
Linear Trend 1932-1955		24.00	0.42808	0.38078	0.37130	0.41503	0.40677	0.43404
Linear Trend 1955-1972		18.00	0.29396	0.32629	0.32132	0.26833	0.28022	0.28069
Oct to Nov Prec (mm)	DFN	35.40		0.11072	0.12108	0.10570	0.11580	0.11653
Mar Prec - P.E.T. (mm)	DFN	18.47			-0.05794	-0.05855	-0.06671	-0.06423
Apr Prec - P.E.T. (mm)	DFN	12.38				0.03065	0.02774	0.02848
Jun Prec (mm)	SDFN	80.43					-0.00032	-0.00035
Jun Degree Days Above 90F							-0.42624	-0.71084
Jul Prec (mm)	DFN	52.33						-0.02726
R Squared			0.65256	0.74061	0.75196	0.77094	0.78390	0.79245
Standard Error (Q/Ha)			3.50238	3.06384	3.03417	2.95389	2.94773	2.92985
Standard Variance (Q/Ha)			12.26669	9.38708	9.20621	8.72550	8.68910	8.58402

Standard Deviation of Yields = 5.80205 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological normals based on 1931-1975

April 1977

COLORADO STATE WINTER WHEAT MODEL

Crop District	Weight	Crop District	Weight
20 Northeast	.3229	90 Southeast	.3198
60 East Central	.3572		

P.E.T. A = 1.162
P.E.T. I = 42.185

April Daylength = 1.0943

Latitude 39°N

May Degree Days Above 90F = 1 if degree days greater than 11, otherwise 0

Degree Day Stations: Burlington, Eads, Limon, and Two Buttes

Variable		Normal	Trend	March	April	May	June
				Truncation			
Overall Constant		1.00	7.59210	7.94000	7.40082	7.82160	8.11366
Linear Trend 1932-1955		24.00	0.18441	0.16577	0.19543	0.18109	0.21146
Linear Trend 1955-1972		18.00	0.20815	0.20506	0.20533	0.25028	0.22504
Aug to Mar Prec (mm)	DFN	180.01		0.03507	0.03334	0.03623	0.03274
Apr Prec - P.E.T. (mm)	DFN	2.60			0.03781	0.02447	0.02730
May Prec (mm)	DFN	61.38				0.02192	0.01502
May Degree Days Above 90F						-2.63938	-2.97134
Jun Prec (mm)	DFN	52.44					0.03751
Jun Prec (mm)	SDFN	52.44					-0.00099
R Squared			0.39298	0.55217	0.62720	0.71334	0.77539
Standard Error (Q/Ha)			3.13178	2.72340	2.51647	2.26552	2.06186
Standard Variance (Q/Ha)			9.80805	7.41689	6.33262	5.13259	4.25128

Standard Deviation of Yields = 3.92509 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

KANSAS STATE WINTER WHEAT MODEL

Crop District	Weight	Crop District	Weight
10 Northwest	.1129	60 South Central	.2289
20 West Central	.1229	70 Northeast	.0232
30 Southwest	.1838	80 East Central	.0268
40 North Central	.1088	90 Southeast	.0442
50 Central	.1486		

P.E.T. A = 1.481
P.E.T. I = 62.781

March Daylength = .986

Latitude 38°N

May Degree Days Above 90F = 1 if degree days greater than 8, otherwise 0

Degree Day Stations: Ashland, Columbus, Hays, Horton, McPherson, Medicine Lodge, Tribune, and Winfield

			Truncation				
Variable		Normal	Trend	February	March	May	June
Overall Constant		1.00	6.46755	6.52160	7.34792	8.44072	8.52820
Linear Trend 1932-1955		24.00	0.20495	0.21948	0.16876	0.16375	0.17255
Linear Trend 1955-1972		18.00	0.53223	0.47694	0.51856	0.49335	0.48846
Aug to Feb Prec (mm)	DFN	262.17		0.01490	0.01048	0.00920	0.00903
Mar Prec - P.E.T. (mm)	DFN	20.44			0.04324	0.03806	0.04159
Mar Prec - P.E.T. (mm)	SDFN	20.44			-0.00011	-0.00007	-0.00010
May Prec (mm)	SDFN	90.62				-0.00037	-0.00029
May Degree Days Above 90F						-1.06978	-1.13655
Jun Prec (mm)	DFN	97.82					-0.00487
Jun Prec (mm)	SDFN	97.82					-0.00011
R Squared			0.79421	0.82936	0.88253	0.90622	0.91478
Standard Error (Q/Ha)			2.34670	2.16346	1.84164	1.69063	1.65831
Standard Variance (Q/Ha)			5.50698	4.68057	3.39164	2.85821	2.74999

Standard Deviation of Yields = 5.05131 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

MONTANA STATE WINTER WHEAT MODEL

Crop District	Weight	Crop District	Weight
20 North Central	.5309	70 Southwest	.0248
30 Northeast	.1164	80 South Central	.1106
50 Central	.1520	90 Southeast	.0653

P.E.T. A = 1.019
P.E.T. I = 32.660

April Daylength = 1.1251
May Daylength = 1.2479

Latitude 47°

June Degree Days Above 90F = 1 if degree days greater than 25

Degree Day Stations: Dunkirk, Ekalaka, Glendive, Poplar, and Roundup

				Truncation			
Variable		Normal	Trend	March	April	May	June
Overall Constant		1.00	8.75507	9.30470	9.30854	9.86961	9.98028
Linear Trend 1932-1955		24.00	0.25954	0.27801	0.27793	0.24736	0.22862
Linear Trend 1955-1972		18.00	0.27261	0.22537	0.22562	0.22954	0.28194
Aug to Mar Prec (mm)	DFN	150.23		0.03264	0.03265	0.03247	0.01604
Aug to Mar Prec (mm)	SDFN	150.23		-0.00066	-0.00066	-0.00062	-0.00042
Apr Prec - P.E.T. (mm)	SDFN	-2.68			-0.00001	-0.00021	-0.00027
May Prec - P.E.T. (mm)	DFN	-24.68				0.02820	0.02919
Jun Prec (mm)	DFN	75.14					0.03948
Jun Degree Days Above 90F							-1.61690
R Squared			0.63547	0.69797	0.69797	0.73576	0.83514
Standard Error (Q/Ha)			2.59831	2.42496	2.45665	2.32870	1.89119
Standard Variance (Q/Ha)			6.75120	5.88043	6.03514	5.42283	3.57661

Standard Deviation of Yields = 4.20223 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

NEBRASKA WINTER WHEAT MODEL

Crop District	Weight	Crop District	Weight
50 Central	.0531	80 South Central	.1802
60 East Central	.1434	90 Southeast	.2415
70 Southwest	.3810		

P.E.T. A = 1.337
P.E.T. I = 53.681

April Daylength = 1.1013

Latitude 41°N

June Degree Days Above 90F = 1 if degree days greater than 40, otherwise 0

Degree Day Stations: Bridgeport, Broken Bow, Franklin, Gothenburg, and Harrison

Variable		Normal	Trend	October	Truncation April	May	June
Overall Constant		1.00	7.2[illegible]257	7.90856	8.11517	8.38599	8.86406
Linear Trend 1932-1955		24.00	0.26264	0.24905	0.24898	0.22805	0.27020
Linear Trend 1955-1972		18.00	0.59216	0.51854	0.50694	0.52228	0.47975
Oct Prec (mm)	DFN	34.98		0.06236	0.06092	0.05704	0.04920
Apr Prec/P.E.T. (mm)	SDFN	1.37			-0.15399	-0.12129	-0.15119
May Temp (°C)	DFN	16.36				-0.50631	-0.57682
Jun Prec (mm)	DFN	102.75					-0.03267
Jun Prec (mm)	SDFN	102.75					-0.00017
Jun Degree Days Above 90F							-1.80363
R Squared			0.76760	0.82228	0.83033	0.85610	0.90113
Standard Error (Q/Ha)			2.94581	2.60805	2.58075	2.40783	2.07961
Standard Variance (Q/Ha)			8.67778	6.80193	6.66027	5.79763	4.32478

Standard Deviation of Yields = 5.96688 Q/Ha

DFN = Departure from Norman
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

OKLAHOMA WINTER WHEAT MODEL

Crop District	Weight	Crop District	Weight
20 West Central	.1741	50 Central	.1404
30 Southwest	.2393	60 South Central	.0101
40 North Central	.4116		

P.E.T. A = 1.747
P.E.T. I = 78.287

March Daylength = .9870

Latitude 36°N

May Degree Days Above 90F = 1 if degree days greater than 15

Degree Day Stations: Gage, Ponca City, Oklahoma City, and Hobart

Variable		Normal	Trend	Truncation February	Truncation March	Truncation May	Truncation June
Overall Constant		1.00	6.72745	6.40407	6.90365	7.44577	7.39009
Linear Trend 1932-1955		24.00	0.04555	0.10065	0.06885	0.14057	0.13615
Linear Trend 1955-1960		6.00	1.42461	1.21001	1.24222	0.94608	0.95280
Aug to Feb Prec (mm)	DFN	337.18		0.00852	0.00642	0.00573	0.00649
Mar Prec - P.E.T. (mm)	DFN	19.24			0.03191	0.03812	0.03892
May Prec (mm)	DFN	110.61				-0.01227	-0.01317
May Prec (mm)	SDFN	110.61				-0.00018	-0.00015
May Degree Days Above 90F						-0.76836	-0.74637
Jun Prec (mm)	DFN	95.14					-0.00794
R Squared			0.72583	0.75285	0.81232	0.89479	0.90005
Standard Error (Q/Ha)			2.30706	2.21763	1.95714	1.52515	1.50766
Standard Variance (Q/Ha)			5.32252	4.91790	3.83039	2.32608	2.27305

Standard Deviation of Yields = 4.30235 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

TEXAS-EDWARDS PLATEAU WINTER WHEAT COVARIANCE MODEL

Yield and climatic data are pooled over Crop District 70 - Edwards-Plateau (1931-1975), and
Crop Districts 81 - South Central, and 82 - Coastal Border (1961-1975)

Crop Region Constant for 81 and 82 = 1 if data from Crop Districts 81 and 82

P.E.T. A = 2.153
P.E.T. I = 98.412

March Daylength = .9897

Latitude 30°N

Variable		Normal	Trend	Truncation December	January	February	March	May
Overall Constant		1.00	5.78330	6.63156	6.74919	6.91621	7.11875	6.98274
Crop Districts 81 and 82 Constant			2.26560	2.51511	3.28052	2.26901	2.62183	2.27724
Linear Trend 1931-1975		45.00	0.08875	0.06688	0.05503	0.06650	0.07237	0.06880
December Temp (°C)	DFN	10.54		-0.34799	-0.30338	-0.21992	-0.21403	-0.18298
Sep to Dec Prec (mm)	DFN	250.05		0.01012	0.00967	0.00914	0.00829	0.00882
Sep to Dec Prec (mm)	SDFN	250.05		-0.00003	-0.00002	-0.00002	-0.00002	-0.00002
Jan Temp (°C)	DFN	9.36			-0.31191	-0.27000	-0.21786	-0.22080
Feb Prec (mm)	DFN	44.28				0.03670	0.03228	0.03355
Feb Prec (mm)	SDFN	44.28				-0.00029	-0.00037	-0.00034
Mar Prec - P.E.T. (mm)	DFN	-9.55					0.02874	0.02812
Mar Prec (mm)	SDFN	34.03					-0.00069	-0.00073
May Temp (°C)	SDFN	23.51						0.30252
R Squared			0.42859	0.59545	0.64615	0.74161	0.81301	0.83121
Standard Error (Q/Ha)			2.17809	1.88384	1.77871	1.55007	1.34581	1.29218
Standard Variance (Q/Ha)			4.74406	3.54886	3.16382	2.40272	1.81119	1.66973

Standard Deviation of Yields = 2.83127 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

April 1977

TEXAS LOW PLAINS WINTER WHEAT MODEL

Crop District	Weight	Crop District	Weight
21 North Low Plains	.6518	30 Cross Table	.3482
22 South Low Plains	.6518	40 Black Lands	.3482

P.E.T. A = 1.943
P.E.T. I = 88.552

March Daylength = .9884
June Daylength = 1.1819

Latitude = 33°N

Variable		Normal	Trend	Truncation February	Truncation March	Truncation May	Truncation June
Overall Constant		1.00	6.60605	6.38475	6.31492	6.37092	6.85054
Linear Trend 1932-1955		24.00	-0.01258	0.03182	0.03510	0.04164	0.03281
Linear Trend 1955-1972		6.00	1.05620	0.87040	0.87947	0.82593	0.81955
Aug to Feb Prec (mm)	DFN	344.73		0.00764	0.00508	0.00509	0.00403
Mar Prec - P.E.T. (mm)	DFN	6.01			0.02516	0.02421	0.02527
May Prec (mm)	DFN	101.08				-0.00764	-0.00770
Jun Prec - P.E.T. (mm)	SDFN	-87.71					-0.00013
R Squared			0.71138	0.75856	0.80754	0.81828	0.83710
Standard Error (Q/Ha)			1.60316	1.48452	1.34231	1.32135	1.26785
Standard Variance (Q/Ha)			2.57014	2.20379	1.80180	1.74595	1.60745

Standard Deviation of Yields = 2.91391 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

Texas-Oklahoma Panhandle Winter Wheat Model

Crop District	Weight	Crop District	Weight
10 Panhandle (Oklahoma)	.3155	11 North High Plains (Texas)	.6845
		12 South High Plains (Texas)	.6845

P.E.T. A = 1.584
P.E.T. I = 69.050

March Daylength = .9875
April Daylength = 1.0815

Latitude 35°N

May Degree Days Above 90F = 1 if degree days greater than 40

Degree Day Stations: Oklahoma: Gage; Texas: Miami, Plainview, and Spearman

Variable		Normal	Trend	Truncation February	Truncation March	Truncation April	Truncation May
Overall Constant		1.00	4.29829	3.91764	4.30683	4.11932	4.33698
Linear Trend 1932-1955		24.00	0.08359	0.14643	0.13063	0.11344	0.12940
Linear Trend 1955-1960		6.00	1.29838	1.05759	1.03194	1.20067	1.21273
Aug to Feb Prec (mm)	DFN	216.04		0.02425	0.01961	0.01639	0.01535
Mar Prec - P.E.T. (mm)	DFN	-1.64			0.04775	0.02750	0.02229
Apr Prec/P.E.T. (mm)	DFN	0.64				2.17928	2.50331
May Prec (mm)	DFN	71.04					0.00547
May Prec (mm)	SDFN	71.04					-0.00021
May Degree Days Above 90F							-1.40682
R Squared			0.65756	0.76651	0.83259	0.86386	0.89043
Standard Error (Q/Ha)			2.65560	2.22007	1.90381	1.73924	1.62582
Standard Variance (Q/Ha)			7.05222	4.92870	3.62450	3.02495	2.64330

Standard Deviation of Yields = 4.43125 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Winter Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

MINNESOTA STATE ING WHEAT MODEL

Crop District	Weight	Crop District	Weight
50 Central	.5466	80 South Central	.1888
70 Southwest	.2646		

P.E.T. A = 1.154
P.E.T. I = 41.691

April Daylength = 1.1126

Latitude = 44°N

Variable		Normal	Trend	March	April	May	June	July	August
				Truncation					
Overall Constant		1.00	10.84268	10.58601	10.87238	12.04053	11.67521	11.70925	11.27434
Linear Trend 1955-1975		21.00	0.64939	0.69385	0.70572	0.68056	0.73142	0.71421	0.73717
Oct to Mar Prec (mm)	DFN	170.60		-0.01607	-0.01761	-0.02340	-0.03456	-0.03752	-0.03869
Apr Prec - P.E.T. (mm)	DFN	25.86			-0.00929	-0.01387	-0.03551	-0.03624	-0.04149
Apr Prec - P.E.T. (mm)	SDFN	25.86			-0.00042	-0.00038	-0.00021	-0.00021	-0.00048
May Prec (mm)	DFN	88.33				-0.01936	-0.01838	-0.02596	-0.02535
May Temp (°C)	SDFN	14.23				-0.25773	-0.28873	-0.27535	-0.27818
Jun Temp (°C)	DFN	19.68					-1.06660	-1.01957	-0.93314
Jul Temp (°C)	DFN	22.52						-0.77061	-0.85496
Aug Temp (°C)	SDFN	21.23							0.29925
R Squared			0.68966	0.71579	0.72652	0.78386	0.87829	0.92248	0.93958
Standard Error (Q/Ha)			2.90493	2.81365	2.82993	2.58290	1.96499	1.59042	1.42461
Standard Variance (Q/Ha)			8.43862	7.91665	8.00849	6.67137	3.86118	2.52943	2.02953

Standard Deviation of Yields = 5.15357 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Spring Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

MONTANA STATE SPRING WHEAT MODEL

Crop District	Weight	Crop District	Weight
20 North Central	.2962	90 Southeast	.0399
30 Northeast	.6639		

P.E.T. A = 1.050
P.E.T. I = 34.726

May Daylength = 1.2573
July Daylength = 1.2826

Latitude = 48°N

Variable		Normal	Trend	Truncation March	May	June	July
Overall Constant		1.00	6.04195	6.17384	6.54871	5.88880	6.14357
Linear Trend 1932-1955		24.00	0.18709	0.18001	0.16158	0.18883	0.17131
Linear Trend 1955-1972		18.00	0.28296	0.28183	0.26991	0.29506	0.30740
Aug to Mar Prec (mm)	DFN	135.10		0.02219	0.02205	0.01966	0.01580
May Prec - P.E.T. (mm)	DFN	-32.57			0.02240	0.01162	0.00630
Jun Prec (mm)	DFN	76.65				0.05717	0.05854
Jul Prec - P.E.T. (mm)	DFN	-95.83					0.02850
R Squared			0.58793	0.62313	0.65471	0.82466	0.85531
Standard Error (Q/Ha)			2.49052	2.41136	2.33753	1.68752	1.55349
Standard Variance (Q/Ha)			6.20267	5.81463	5.46405	2.84773	2.41335

Standard Deviation of Yields = 3.78845 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Spring Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

NORTH DAKOTA S NG WHEAT MODEL

Crop District	Weight	Crop District	Weight
10 Northwest	.2509	70 Southwest	.0948
20 North Central	.1558	80 South Central	.0834
40 West Central	.1178	90 Southeast	.1357
50 Central	.1616		

P.E.T. A = 1.051
P.E.T. I = 34.813

April Daylength = 1.1297
May Daylength = 1.2573

Latitude = 48°N

June Degree Days Above 90F = 1 if degree days greater than 2, otherwise 0
July Degree Days Above 90F = 1 if degree days greater than 15, otherwise 0

Degree Day Stations: Bismarck, Dickinson, Fargo, Grand Forks, Jamestown, Minot, and Williston

Variable		Normal	Trend	Truncation March	Truncation April	Truncation May	Truncation June	Truncation July
Overall Constant		1.00	4.25220	5.07375	5.00981	5.12948	6.66911	7.83411
Linear Trend 1932-1955		24.00	0.17973	0.12701	0.14318	0.13230	0.10454	0.08950
Linear Trend 1955-1965		11.00	0.58914	0.68875	0.65567	0.65543	0.68523	0.69733
Linear Trend 1965-1972		8.00	0.26745	0.10780	0.22519	0.23068	0.27639	0.24716
Aug to Mar Prec (mm)	DFN	176.67		0.02966	0.02716	0.02660	0.02589	0.02357
Apr Prec - P.E.T. (mm)	DFN	10.47			-0.00009	-0.00658	-0.00297	0.00181
Apr Prec - P.E.T. (mm)	SDFN	10.47			-0.00042	-0.00035	-0.00046	-0.00041
May Prec/P.E.T. (mm)	DFN	0.77				1.24698	1.44860	0.70176
Jun Prec (mm)	DFN	89.26					0.04159	0.03738
Jun Prec (mm)	SDFN	89.26					-0.00044	-0.00045
Jun Degree Days Above 90F							-1.29241	-0.88576
Jul Degree Days Above 90F								-1.55418
R Squared			0.69401	0.74860	0.76076	0.76959	0.87180	0.88325
Standard Error (Q/Ha)			2.83090	2.59865	2.60266	2.58938	2.01738	1.95503
Standard Variance (Q/Ha)			8.01400	6.75300	6.77386	6.70489	4.06982	3.82215

Standard Deviation of Yields = 4.93589 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Spring Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

April 1977

RED RIVER VALL SPRING WHEAT

Crop District	Weight	Crop District	Weight
10 Northwest (Minnesota)	.2704	30 Northeast (North Dakota)	.3643
40 West Central (Minnesota)	.1372	60 East Central (North Dakota)	.2282

June Degree Days Above 90F = 1 if degree day greater than 2, otherwise 0
July Degree Days Above 90F = 1 if degree day greater than 15, otherwise 0

Degree Day Stations: Fargo and Grand Forks

Variable	Normal	Trend	Truncation March	Truncation April	Truncation June	Truncation July
Overall Constant	1.00	6.54915	6.72093	6.93397	7.41326	9.08323
Linear Trend 1932-1955	24.00	0.24442	0.23700	0.25010	0.25833	0.22687
Linear Trend 1955-1972	18.00	0.53047	0.52334	0.50615	0.48786	0.48381
Aug to Mar Prec (mm) DFN	241.73		0.01138	0.01282	0.01094	0.00517
Apr Temp (°C) DFN	4.76			0.31719	0.26453	0.31178
Apr Temp (°C) SDFN	4.76			-0.07882	-0.07012	-0.06971
Jun Degree Days Above 90F					-1.07363	-1.17887
Jul Degree Days Above 90F						-1.97924
R Squared		0.80293	0.81621	0.83916	0.84846	0.87719
Standard Error (Q/Ha)		2.40579	2.35218	2.25760	2.22072	2.02677
Standard Variance (Q/Ha)		5.78783	5.53273	5.09676	4.93161	4.10778

Standard Deviation of Yields = 5.29179 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Spring Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975

SOUTH DAKOTA SPRING WHEAT MODEL

Crop District	Weight	Crop District	Weight
10 Northwest	.1471	50 Central	.1253
20 North Central	.4294	60 East Central	.0364
30 Northeast	.2483	90 Southeast	.0135

P.E.T. A = 1.146
P.E.T. I = 41.109

April Daylength = 1.1166

Latitude = 45°N

June Degree Days Above 90F = 1 if degree days greater than 25, otherwise 0

Degree Day Stations: Aberdeen, Huron, Pierre, Rapid City, and Watertown

Variable		Normal	Trend	Truncation March	Truncation April	Truncation June	Truncation July
Overall Constant		1.00	4.72604	5.20073	5.83441	7.12846	7.53465
Linear Trend 1932-1955		24.00	0.13226	0.10167	0.11531	0.07897	0.04088
Linear Trend 1955-1972		18.00	0.38312	0.39511	0.35686	0.40911	0.42212
Aug to Mar Prec (mm)	DFN	184.03		0.02282	0.02083	0.01295	0.00860
Apr Prec/P.E.T. (mm)	DFN	1.67			0.95764	0.72548	0.72397
Apr Prec/P.E.T. (mm)	SDFN	1.67			-0.49960	-0.57424	-0.52912
Jun Prec (mm)	DFN	90.61				0.01965	0.01707
Jun Degree Days Above 90F						-3.08619	-2.64223
Jul Temp (°C)	DFN	22.97					-0.39620
R Squared			0.59776	0.65062	0.70325	0.87983	0.89677
Standard Error (Q/Ha)			2.64253	2.49339	2.35763	1.54137	1.44890
Standar Variance (Q/Ha)			6.98295	6.21701	5.55841	2.37582	2.09930

Standard Deviation of Yields = 4.06850 Q/Ha

DFN = Departure from Normal
SDFN = Squared Departure from Normal
Yields Measured in Quintals per Hectare

Weights Based on 1973 Spring Wheat Harvested Acreage
Yields Based on 1932-1975
Meteorological Normals Based on 1931-1975